Optimization Models for Restaurant Revenue Management

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The problem

- The floor manager of a restaurant has a party of 4 people waiting for a table and a free table of size 6
- To sit or not to sit the party?
- And, if there are more tables that are free...
- Where to sit the party in order to maximize the revenue?

Revenue Management

- Collection of strategies and tactics for manage demand

- Revenue management is concerned with the methodology and systems required to make demand management decisions, which can be categorized into

- Structural decisions
- Price decisions
- Quantity decisions

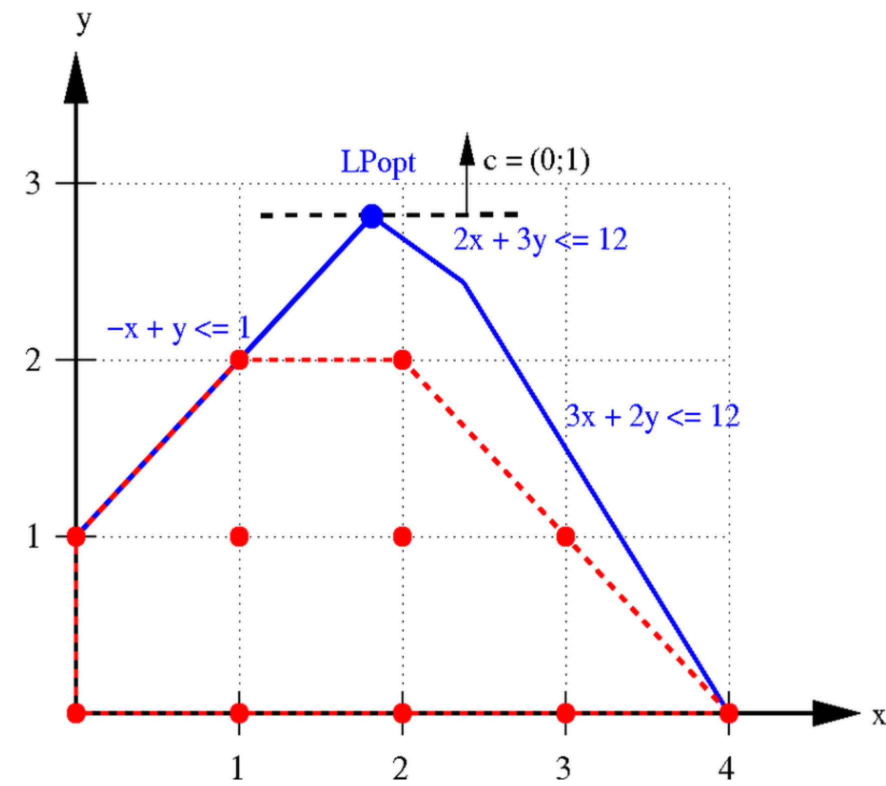
Revenue Management

- Why can revenue management be useful for restaurants?
- It is used extensively in airlines, hotels, car industries and can be applied for restaurants
  - Focus on Quantity decisions

Integer Linear Programming

- Max y

- $-x+y \leq 1$
- $3x+2y \leq 12$
- $2x+2y \leq 12$
- $x,y \geq 0$
- $x,y \in Z$



Two IP models

- Presented by Bertsimas and Shioda, will be implemented in AMPL and CPLEX

- Basic Deterministic Model: will focus only on parties in the queue

- Improved model: will make an estimations on future customers and behave accordingly

Basic Model

- The data needed are: the number of tables, the revenue for each party, the cost of denying service to a party, M and η (user-defined)
- The state is: the current period, the parties in the queue, the parties seated
- The decision variable is the number of party to be seated

Demand Costraints

$$\sum_{\substack{t'=now,\dots,T \\ k'=k,\dots,K}} q_{t,t',k,k'} + qdeny_{t,k} = Q_{t,k}$$

$$\forall t = 1,\dots.,now; k = 2,\dots.,K$$

Seating-Capacity Constraints

$$\sum_{k=2,\ldots,k'} \sum_{t,t'=1,\ldots,T} q_{t,t',k,k'} + \sum_{k=2,\ldots,k'} N^{s}_{k,k'} \leq c_{k'}$$

$$\forall k' = 2,\ldots,K$$

Fairness Costraints

$$\sum_{\substack{t=1,\dots,T \\ k'=k,\dots,K}} (Q_{t,k} - q_{t,now,k,k'}) \leq \Big(\sum_{t=1,\dots,T} Q_{t,k}\Big) z^{q}_{t,k}$$

$$\sum_{k'=k,\dots,K} q_{t,now,k,k'} \leq L(1 - z^{q}_{t,k})$$

$$\forall \quad t = 1,\dots,now; k = 2,\dots,K$$

Objective Function

$$\max \sum_{\substack{t=1,\ldots,now \\ k=2,\ldots,K}} \sum_{\substack{k'=k,\ldots,K \\ t'=now,\ldots,T}} (R_K - M(t'-t) - \eta(k'-k))q_{t,t',k,k'}$$

$$- \sum_{\substack{t=1,\ldots,now \\ k=2,\ldots,K}} CostQ_{t,k}\, qdeny_{t,k}$$

Improved Model

- It will use all the data from the basic model plus an estimation on future parties and the cost of denying service to them

- Few changes in the constraints and the objective function

AMPL & CPLEX

- AMPL: algebraic modeling language, it supports integer, quadratic, mixed-integer programming.

- CPLEX: optimization software package. It is used to solve IP problems as well as variuos others

The Simulation

- The model at each period will:
- Decide which party to seat, when and where
- Seat the parties for the current period
- Put the other parties in the queue

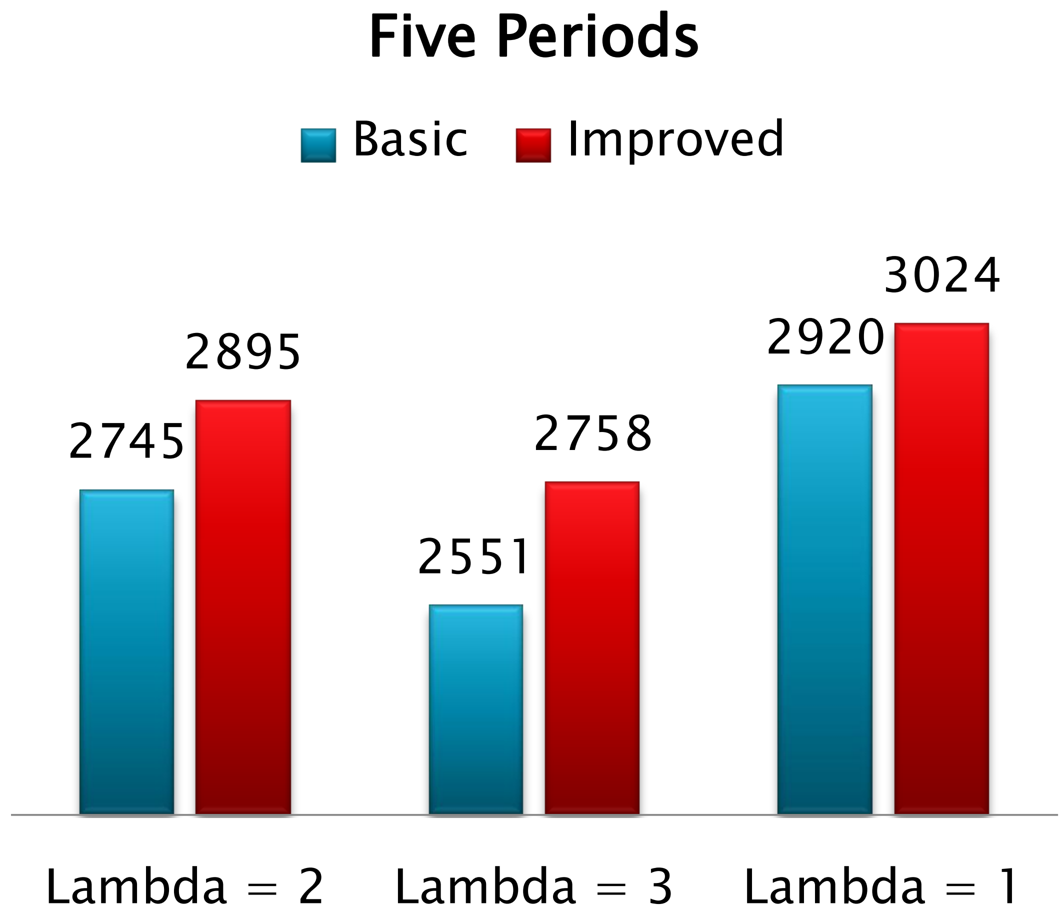
The Simulation

- The revenue, the costs and the size of the restaurant is decided arbitrarily.
- The user-defined parameter are found experimentally
- Customers given by Poisson distribution

Improved vs Basic

Improved model yelds always better results

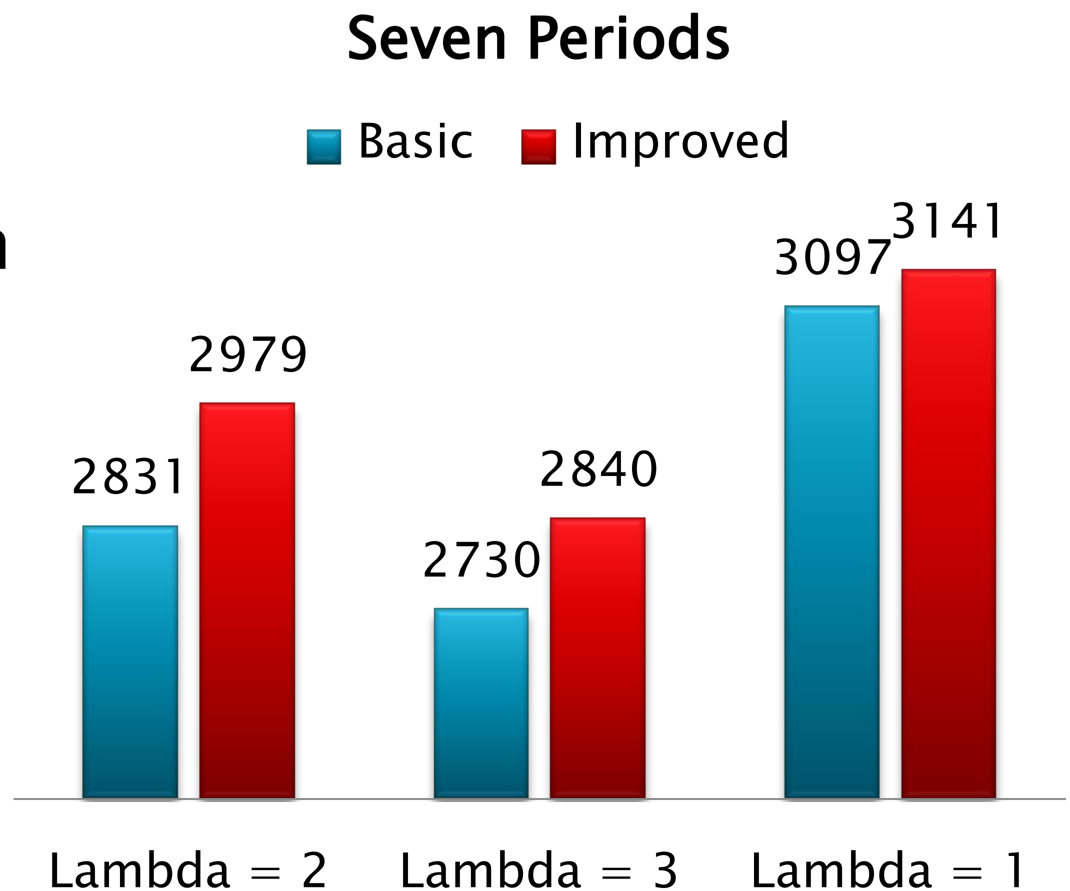
The values of the basic model are more scattered



Using smaller periods

The use of smaller periods will produce an increase in revenue

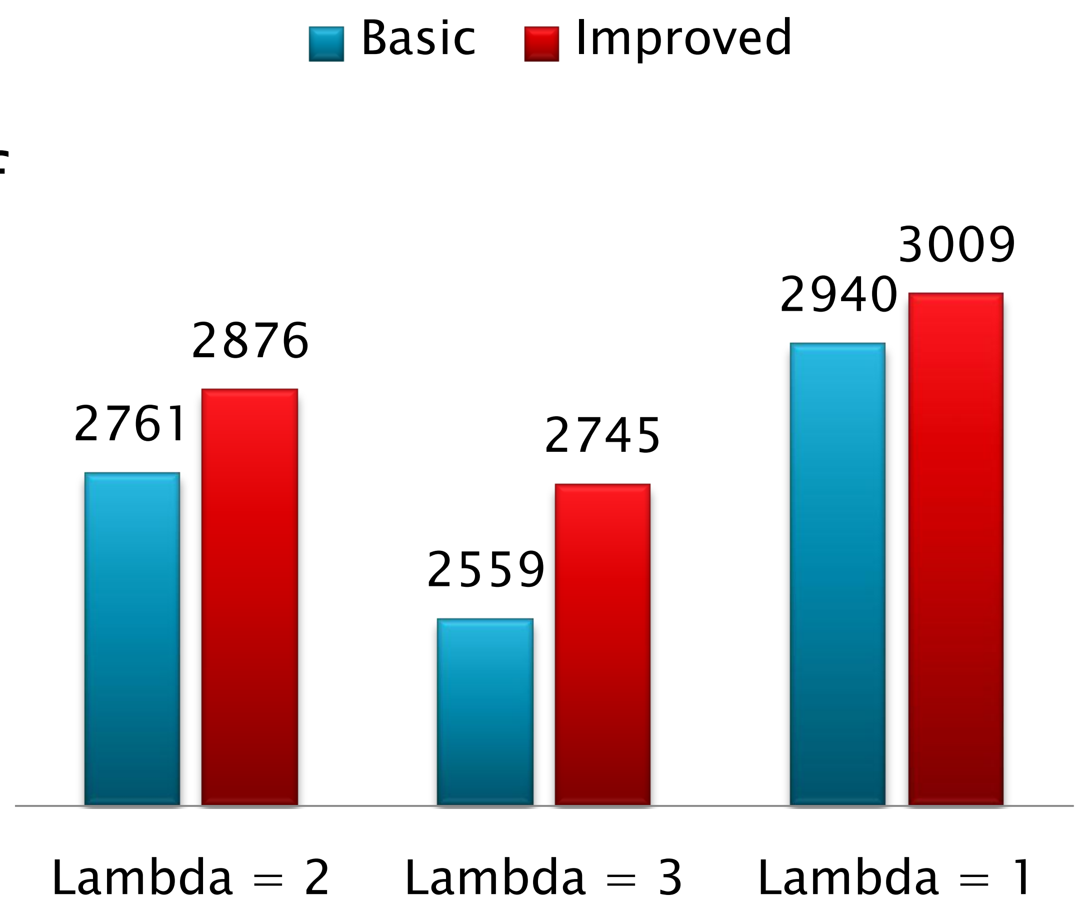
Because of the gained flexibility



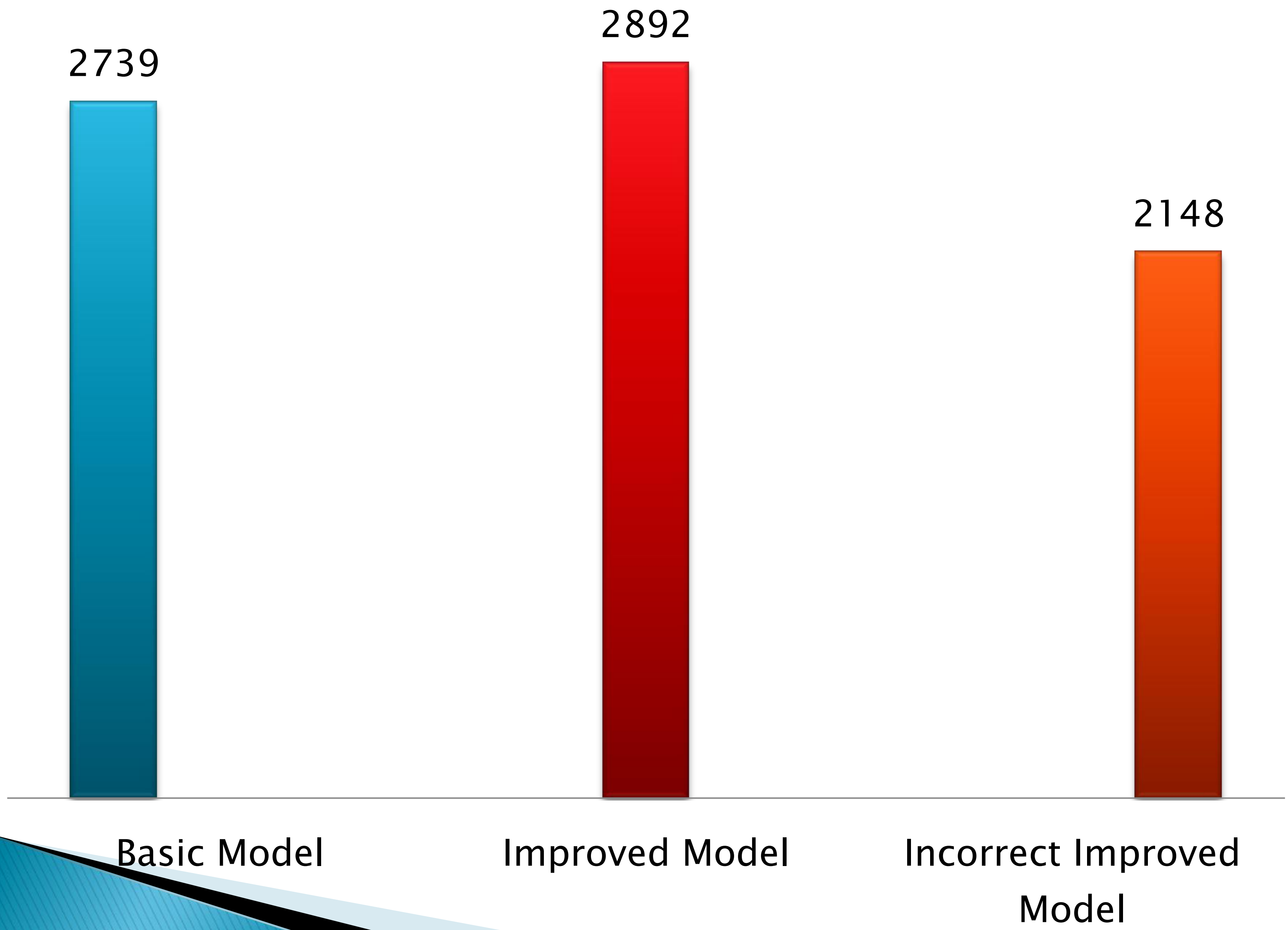
Variable time at tables

Very small shrinkage of the difference

Because of difference between expected and real customers



Wrong estimations



Future possible additions

- The models handle quite well reservations, it simply can leave out the reserved tables
- A possible future improvement could be to consider the possibility that the party will arrive late or that there is a no-show

Final Considerations

- The improved model is preferable with respect to the basic model when there are correct estimations
- Using smaller periods leads to better results
- The use of an average time does not effect greatly the results

Thank you for your attention!